

THE BALSAMINACEAE IN THE
SOUTHEASTERN UNITED STATES¹

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BALSAMINACEAE A. Richard, Dict. Class. Hist. Nat. 2: 173. 1822,
"Balsamineae," nom. cons.
(TOUCH-ME-NOT FAMILY)

Annual [or perennial] herbs [sometimes epiphytic, or subshrubs] with simple, alternate [opposite or whorled] exstipulate leaves. Flowers perfect, protandrous, zygomorphic, axillary, solitary, or clustered. Sepals 3 [5], the apparent lowest or posterior one (the flowers resupinate) \pm saccate and [usually] spurred, the spur nectariferous, the 2 lateral sepals free [or connate]. Petals 5 [free] or by connation of the lateral petals in pairs appearing to be 3. Stamens 5, alternate with the petals; filaments short, free or \pm connate, in ours with a scalelike appendage on the inner side, the scales partly united over the gynoecium; anthers 2-locular [coherent or] connivent, opening by a slit or pore. Gynoecium [4- or] 5-carpellate, syncarpous; stigmas 5, minute, sessile [or style short, subulate, stigma 1]; ovary superior [4- or] 5-loculate, each locule with 2 to many anatropous, 2-integumented ovules, the placentation axile. Fruit a \pm fleshy [4- or] 5-valved capsule, usually opening elastically, or (in *Tytonia*) drupaceous or a fleshy capsule(?). Seeds with a straight embryo and without endosperm. TYPE GENUS: *Balsamina* P. Miller, nom. illegit. = *Impatiens* L.

A family of three genera and some 500 described species. *Tytonia* G. Don (*Hydrocera* Blume ex Wight & Arnott) comprises only a single species, *T. triflora* (L.) C. E. Wood (*Hydrocera triflora* (L.) Wight &

¹Prepared for the Generic Flora of the Southeastern United States, a joint project of the Arnold Arboretum and the Gray Herbarium of Harvard University made possible through the support of the National Science Foundation, currently under Grant BMS74-21469 (Carroll E. Wood, Jr., principal investigator). This treatment, the seventy-sixth in the series, follows the pattern established in the first paper (Jour. Arnold Arb. 39: 296-346. 1958) and continued to the present. The area covered by the Generic Flora includes North and South Carolina, Georgia, Florida, Tennessee, Alabama, Mississippi, Arkansas, and Louisiana. The descriptions apply primarily to the plants of this area, with supplementary information in brackets. References that the author has not verified are marked with an asterisk.

A preliminary paper on the Balsaminaceae written by Dr. K. A. Wilson for the Generic Flora project has been consulted in the preparation of this treatment. Beverly Vincent has aided in the preparation of the bibliography and the typing of the manuscript. The illustration was drawn by A. D. Clapman under the direction of the author. The material for the drawing of *Impatiens pallida* was collected by R. B. Channell and H. F. L. Rock.

Arnott),² $2n = 16$, of marshes from India to Java. *Semeiocardium* Zoll. is also monotypic, including only *S. Arriensii* Zoll., known solely from Madura and Kangean islands off the northeast coast of Java. *Impatiens* L. comprises the remainder of the species.

The family is a distinct one, characterized by the simple, exstipulate leaves, watery sap, resupinate zygomorphic flowers with a usually spurred often saccate sepal, stamens that are coherent around the gynoecium, and (in *Impatiens* and *Semeiocardium*) elastic dehiscence of the capsule. The fruit of *Tytonia* has been variously described as a berry; or as succulent, drupaceous, 5-angled, 5-furrowed, 5-loculate, the endocarp hard and bony, the seeds solitary (Wight & Arnott, p. 140); or as a 5-pyrenous drupe, "the stones 3-4 celled; only 1-2 cells seed-containing; the other ones empty and serving as a floating apparatus" (Backer & Bakhuizen, Fl. Java); or most recently as a purplish-red capsular berry dehiscing septicidally from the top leaving the seed attached to the column (Venkateswarlu & Dutt).

In *Tytonia* the perianth consists of five sepals (one spurred) and five petals, the lowermost largest. In *Impatiens* there are usually only three sepals (one saccate and usually spurred and two smaller lateral ones), but some species (cf. Hooker) have five, the two additional ones smaller than the others. The uppermost petal is free (and is often carinate or bifid), and the four others are connate in pairs, the pairs free from each other, each usually giving the appearance of a single two-lobed petal, but in *I. Wallerana* free nearly to the base and equal in size. An earlier interpretation of the perianth as composed of four sepals (the fourth [the uppermost petal in the above interpretation] being petaloid and often notched, presumably representing two sepals) and four petals (united in pairs) seems unlikely in view of the 10 perianth segments of *Tytonia* and the five sepals of some species of *Impatiens*. The perianth of *Semeiocardium* is composed of three sepals and five petals as in *Impatiens*, but the two fused petal-pairs have become connate into a bifid two-clawed liplike structure. *Semeiocardium* differs further from *Tytonia* and *Impatiens* in the largely connate lateral sepals, the 4-locular ovary, and the short, subulate style with a single stigma. Although it was originally described by Zollinger as a member of the Balsaminaceae, first Hasskarl and then Chodat mistakenly assigned it to the Polygalaceae. However, Backer's observations on living plants show that it is closely allied with *Impatiens* (cf. Miller, Jour. Arnold Arb. 52: 273. 1971).

² As Backer & Bakhuizen van den Brink (Fl. Java 1: 251. 1963) pointed out a dozen years ago, Blume (Bijdr. Fl. Nederl. Indië 241. 1825) did not publish the generic name *Hydrocera* validly, since he gave only a family description (Hydrocereae) and neither a generic description nor a specific one that might serve as a combined generic-specific description. *Hydrocera* was first validly published by Wight & Arnott (Prodr. Fl. Penin. Indiae Orient. 140. 1834), but they cited *Tytonia* G. Don (Gen. Syst. Garden. Bot. 1: 749. 1831) in synonymy, making *Hydrocera* superfluous and illegitimate. The single species in this genus should be known as *Tytonia triflora* (L.) C. E. Wood, comb. nov., basionym, *Impatiens triflora* L. Sp. Pl. 2: 938. 1753.

The Balsaminaceae have been considered to be allied with the Geraniales, and they have even been included in the Geraniaceae, but neither position is supported by recent studies. Most recent students have placed the family with the Sapindales, but this association is also uncertain. Erdtman notes that "an affinity with Celastrales, Geraniaceae, Oxalidaceae, Simaroubaceae, or Violaceae has been suggested but is not supported by pollen morphology."

REFERENCES:

- BACKER, C. A. *Semeiocardium* Zoll., a misinterpreted genus of Balsaminaceae. Gard. Bull. Singapore 9: 70-72. *pl.* 2. 1935. [Emended description based on living plants.]
- & R. C. BAKHUIZEN VAN DEN BRINK, JR. Flora of Java. Vol. 1. xxiii + 648 pp. *frontisp.* [Balsaminaceae, 248-251.]
- BAILLON, H. Geraniacées. VI. Serie des Balsamines. Hist. Pl. 5: 17-19. 1874.
- BENTHAM, G., & J. D. HOOKER. Geraniaceae. Tribus VII. Balsamineae. Gen. Pl. 1: 277, 278. 1862.
- CANDOLLE, A. P. DE. Balsamineae. Prodr. 1: 685-688. 1824.
- DAVIS, G. L. Systematic embryology of the angiosperms. viii + 528 pp. New York, London, & Sydney. 1966. [Balsaminaceae, 54; numerous references.]
- HEGNAUER, R. Chemotaxonomie der Pflanzen. Band 3. Dicotyledoneae: Acanthaceae-Cyrtaceae. 473 pp. Basel & Stuttgart. 1964. [Balsaminaceae, 229-234.]
- HOOKE, J. D., & T. THOMSON. Praecursores ad Floram Indicam. — Balsamineae. Jour. Linn. Soc. Bot. 4: 106-157. 1860.
- HUYNH, K. L. Morphologie du pollen des Tropaeolacées et des Balsaminacées II. (English summary.) Grana Palyn. 8: 277-516. 1968. [Includes about 450 spp. of *Impatiens* and *Tytonia triflora* (as *Hydrocera*).]
- LUBBOCK, J. A contribution to our knowledge of seedlings. 2 vols. London & New York. 1892. [Balsaminaceae, as "Geraniaceae," 1: 314-316.]
- MARTIN, A. C. The comparative internal morphology of seeds. Am. Midl. Nat. 36: 513-660. 1946. [Balsaminaceae, 626.]
- NARAYANA, L. L. Contributions to the embryology of Balsaminaceae. Jour. Indian Bot. Soc. 42: 102-109. 1963.
- . Contributions to the embryology of Balsaminaceae. 2. Jour. Jap. Bot. 40(4): 8-20. 1965.
- . A contribution to the floral anatomy of Balsaminaceae. *Ibid.* 49: 315-320. 1974.
- POBEDIMOVA, E. G. Balsaminaceae. In: B. K. SHISHKIN & E. G. BOBROV, eds., Fl. URSS. 14: 624-634. 1949. [English translation, Fl. USSR. Israel Program for Sci. Transl. 14: 478-485. 1974. Includes 8 spp. of *Impatiens*.]
- RYDBERG, P. A. Balsaminaceae. N. Am. Flora 25: 93-96. 1910.
- SCHÜRHOFF, P. N. Die Haploidgeneration der Balsaminaceen und ihre Verwertung für die Systematik. Bot. Jahrb. 64: 324-356. *pls.* 14-18. 1931.
- TIEGHEM, P. VAN. Structure de quelques ovules et parti qu'on en peut tirer pour améliorer la classification. Jour. Bot. Morot 12: 197-220. 1898. [210, *Impatiens*, integuments concrescent nearly throughout.]
- TRELEASE, W. A study of North American Geraniaceae. Mem. Boston Soc. Nat. Hist. 4: 71-104. *pls.* 9-12. 1888. [Balsamineae, 98-100; literature, 102, 103.]

- VENKATESWARLU, J., & L. LAKSHMINARAYANA. A contribution to the embryology of *Hydrocera triflora* W. & A. *Phytomorphology* 7: 194–203. 1957. [Allium-type megagametophyte; includes a list of references with some on *Impatiens*.]
- & B. S. M. DUTT. Amended description of *Hydrocera triflora* Wt. & Arn. *Jour. Bombay Nat. Hist. Soc.* 58: 544–546. 1 pl. 1961.
- WARBURG, E. F. Taxonomy and relationship in the Geraniales in the light of their cytology. *New Phytol.* 37: 130–159, 189–210. 1938.
- WARBURG, O., & K. REICHE. Balsaminaceae. *Nat. Pflanzenfam.* III. 5: 383–392. 1895.
- WEBERLING, F. Weitere Untersuchungen zur Morphologie des Unterblattes bei den Dikotylen. *Beitr. Biol. der Pflanzen* 33(1): 17–32. 1957. [I. Balsaminaceae; II. Plumbaginaceae.]
- WILCZEK, R., & M. SCHULZE. Balsaminaceae. *Fl. Congo Belge* 9: 396–428. 1960. [*Impatiens*.]

1. *Impatiens* Linnaeus, *Sp. Pl.* 2: 937. 1753; *Gen. Pl.* ed. 5. 403. 1754.

Annual [or perennial] herbs [to subshrubs, sometimes acaulescent, sometimes epiphytic], usually with succulent stems and alternate [opposite, or pseudoverticillate], simple, exstipulate leaves [but sometimes with a nectary at each side of the leaf base]. Flowers axillary, solitary, in clusters of 2 or 3 [or in panicles]. Sepals 3 [5], the two lateral ones small, the posterior one large (in ours), petaloid, [usually] saccate [or funnel-shaped] and spurred. Petals 5, appearing to be 3, each of the 2-lobed laterals representing a fused pair, the single upper petal free, often carinate and/or more or less bifid. Stamens 5, the filaments short and flat, each bearing a scalelike appendage on the inner side, the scales partly or completely united over the ovary and stigma, the filaments partly connate; anthers introrse, often connate; pollen strongly flattened [3- or] 4-colpate, reticulate [rarely spinulose]. Gynoecium of 5 united carpels; stigmas 5; style short or absent; ovary 5-locular, the septa delicate, compressed by the ovules, the placentation axile, each locule with 3 to many anatropous ovules. Fruit capsular, the 5 fleshy valves elastic, in ours coiling violently from base to apex in dehiscence, scattering the seeds. Seeds with a straight embryo; cotyledons plump, hypocotyl and epicotyl short; endosperm none. LECTOTYPE SPECIES: *I. noli-tangere* L.; see Britton & Brown, *Illus. Fl. No. U. S. Canada.* ed. 2. 2: 440. 1913. (Name Latin, *impatiens*, in reference to the sudden bursting of the ripe fruit when touched.) — TOUCH-ME-NOT.

A genus of about 500 described species in 14 sections (see Warburg & Reiche), primarily of tropical and subtropical Asia (about half of the species in India and Burma) and Africa (about 150 species), with a few in temperate Eurasia and North America and none in either South America or Australia. Five indigenous species, all annuals of sect. *IMPATIENS* (§ *Brachycentron* Warb.), and two naturalized species occur in the United States and Canada; two of the indigenous species occur in our area.

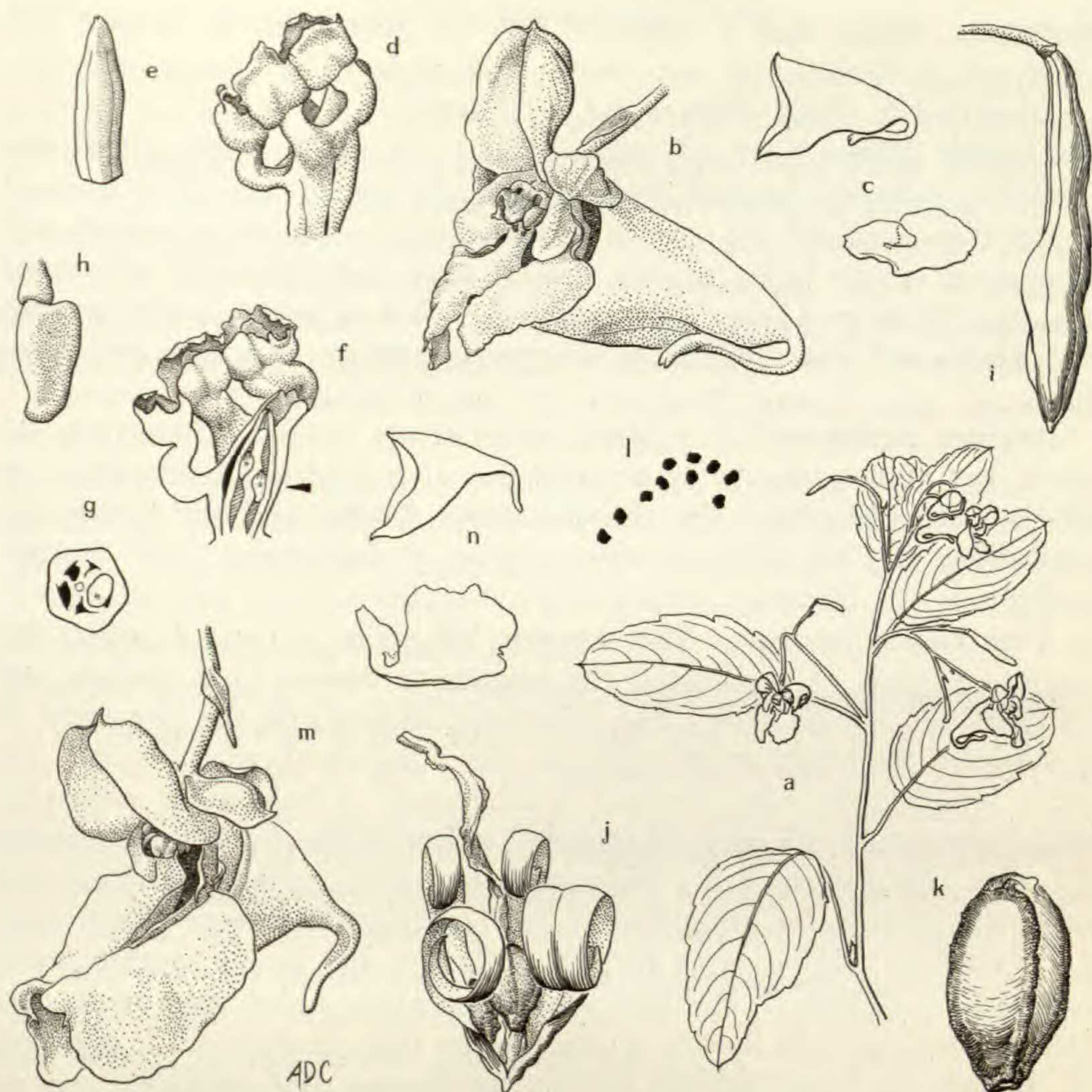


FIGURE 1. *Impatiens*. a-l, *I. capensis*: a, tip of flowering shoot, $\times \frac{1}{2}$; b, flower, $\times 2$; c, spurred sepal and petal-pair (inner surface), $\times 1$; d, androecium inclosing gynoecium, $\times 5$; e, gynoecium, $\times 5$; f, androecium and gynoecium in vertical section, the ovary semidiagrammatic to show central axis with two pendulous ovules in section through micropyle, septa omitted — note fused appendages of stamens covering gynoecium, $\times 5$; g, ovary in cross section at level indicated in "f," $\times 10$; h, pendulous ovule, micropyle at upper right, $\times 15$; i, mature fruit before dehiscence, $\times 2$; j, same, after dehiscence, $\times 2$; k, seed, $\times 5$; l, chromosomes in prometaphase of generative cell division in pollen from herbarium specimen (after Khoshoo, 1957), $\times 1500$. m, n, *I. pallida*: m, flower, $\times 2$; n, spurred sepal and petal-pair (inner surface), $\times 1$.

Impatiens capensis Meerburg (*I. biflora* Walter, *I. fulva* Nutt.), jewelweed, $2n = 20$, is widely distributed in wet places, on stream banks, and in swamps from Newfoundland to Alberta, south to Florida, Alabama, Arkansas, and Oklahoma. The saccate part of the spurred sepal is longer than broad and the sepal spur is usually strongly incurved. The flower color is orange with red spotting, but it is very variable, and numerous color forms have been named (cf. Weatherby). Disjunct populations occur in northwestern Oregon and in extreme northwestern Washington and southwestern British Columbia. Ornduff, who has studied the Oregon

populations, thinks that *I. capensis* may be introduced in Oregon but indigenous in Washington and British Columbia. This species is widely naturalized in Great Britain and in France.

Impatiens pallida Nutt. (*I. aurea* Muhl.), $2n = 20$, with yellow, unspotted or sparingly spotted flowers, with the sac of the spurred sepal broader than long and the spur at a right angle to the sac, occurs in wet places or on stream banks in rich, shaded areas, most often on calcareous soils. It is distributed from Newfoundland to Saskatchewan, south through Nova Scotia and New England to Georgia, Tennessee, Missouri, and Kansas.

Impatiens pallida and *I. capensis*, vegetatively similar, often grow together, but there seems to be no evidence of hybridization anywhere in eastern North America. The chasmogamous flowers of both species are protandrous (as are those of other species of *Impatiens*), and the appendages of the filaments form a cover over the stigmas preventing pollen from falling on them. The stamens fall off as a unit, exposing the receptive stigmas. Unpollinated chasmogamous flowers of *I. pallida* and *I. capensis* do not set fruit. The effective pollinators of the two seem to be different, the rather small sepal sac and orange-and-red color of *I. capensis* favoring the ruby-throated hummingbird (*Archilochus colubris*), which seems to be the only "legitimate" visitor to the flowers both before and after the stamens fall. (Various bees collect pollen, and bees and wasps bite holes in the nectariferous spur, robbing the flowers illegitimately.) *Impatiens pallida*, with its yellow flowers and larger saccate sepal, is visited by species of *Bombus*, which Robertson noted were more constant in their visits to flowers of this species than to those of *I. capensis*. He did not see hummingbirds visiting the flowers of *I. pallida*.

A relatively small proportion of the chasmogamous flowers of either species set fruits, and the bulk of seed production appears to be from cleistogamous flowers. These are much smaller but bear all of the parts present in open ones except for the staminal appendages that cover the stigmas, pollen thus coming directly into contact with the stigmas. The floral parts never expand, but are forced off by the developing fruit. (See Bennett, Carroll, and Gray.)

Ornduff has pointed out that the center of diversity for the genus in North America is in the Pacific Northwest (Oregon, Washington, Idaho, western Montana, and southern British Columbia), where four species occur and the ranges of several overlap. In the northern extreme of its distribution in Oregon on the lower Columbia River, *Impatiens capensis* forms large hybrid swarms with *I. ecalcarata* Blankinship, which has unspotted yellow or orange spurless flowers. The Eurasian *I. noli-tangere* L. (*I. occidentalis* Rydb.), $2n = 20$, which occurs in North America from southern Alaska through British Columbia to northwestern Washington, overlaps the range of *I. ecalcarata* and that of *I. aurella* Rydb., which has relatively small, spurred, unspotted orange flowers. Puzzling plants combining in various ways the morphological features of these four species led Ornduff to hypothesize that "in the Pacific Northwest *I. capensis* was

once widespread, but subsequently the species has largely been exterminated in the region as a result of extensive and widespread hybridization with various other species. Vestiges of the floral morphology and pigment pattern of *I. capensis* still occur, but they are mostly in combination with features derived from *I. noli-tangere*, *I. ecalcarata*, or *I. aurella*. The last species in turn combines characters of *I. ecalcarata* and *I. noli-tangere* and may have originated by means of hybridization between these two species, followed by additional local hybridization with *I. capensis*."

Impatiens glandulifera Royle (*I. Roylei* Walpers) (sect. SALPINGOCHILON Warb.), $2n = 18, 20$, of the Himalayan region, is naturalized in the cooler, moister areas of Nova Scotia, New England, and Quebec, and appears to be spreading in western British Columbia, Washington, and Oregon. It is extensively naturalized in Great Britain, and is spreading in western and central Europe. It is distinctive in its opposite to pseudoverticillate leaves and clusters of large dark magenta-red to rose, pink, or white flowers.

Impatiens parviflora DC. (sect. IMPATIENS), $2n = 20, 24, 26$, a native of central Asia, is now widely naturalized in northern, central, and eastern Europe and in Great Britain, and it is introduced in Prince Edward Island and Quebec and on Vancouver Island, British Columbia. This very small-flowered species apparently is quite variable in its native area, but all of the naturalized plants apparently are descendants from a single seed lot planted in Geneva, Switzerland, about 1830, and are notably uniform. The five-sepaled flowers of *I. parviflora* apparently are largely self-pollinated. (See Coombe for a very complete account of this species in Britain.)

The very variable *Impatiens Balsamina* L. (sect. MICROCENTRON Warb.), $2n = 14$, from India, Malaya, and China, is cultivated in many parts of the world as an ornamental garden plant. This and the African *I. Wallerana* Hooker f. (*I. Sultani* Hook. f., *I. Holstii* Engler & Warb.) (sect. LONGICORNES Warb.), $2n = 16$, notable for a wide range of colors and nearly equal lobing of the paired petals, are probably the two most widely cultivated species of *Impatiens*. Their range of flower colors and ease of cultivation have made them the subject of many physiological, chemical, and genetic studies (see references). Although both are naturalized in various warmer areas, they are only occasional waifs in our region.

Embryo sac development of the Polygonum type (e.g., in *Impatiens capensis*, *I. pallida*, *I. Balsamina*) and of the Allium type (e.g., in *I. Wallerana*, *I. glandulifera*) has been reported in the genus. Species of *Impatiens* are unique in that the strongly flattened pollen is shed while the generative nucleus is in prometaphase of the division that produces the two sperm nuclei; hence the chromosome number can be determined at this stage. This nuclear stage persists in the pollen of herbarium specimens, and it has been possible to obtain chromosome counts from such material (cf. Khoshoo). Diploid chromosome numbers of 12, 14, 16, 20, 26, 32, 34, 36 (+ 2f), 40, and 66 have been recorded in various

species of the genus. These numbers fall into groups based on $x = 7, 8, 10,$ and 11 (cf. Jones & Smith).

Huynh (1968), who studied the pollen of about 450 species of *Impatiens* but who apparently was unaware of the numerous relationships between the floras of North America and Asia, remarked with some surprise that the species of *Impatiens* of North America have pollen which recalls curiously that of the group of *I. noli-tangere*, which includes about 20 species of southern China.

REFERENCES:

- Under family references *Impatiens* is included in all references to Balsaminaeae. Space limitations have dictated that much of the voluminous literature on physiological and chemical studies of *Impatiens* species be omitted. However, some references on each of the general topics are among those below.
- ALSTON, R. E., & C. W. HAGEN. Chemical aspects of the inheritance of flower color in *Impatiens Balsamina* L. *Genetics* 43: 35–47. 1958.
- ANDREWS, F. M. An unusual *Impatiens biflora*. *Proc. Indiana Acad. Sci.* 34: 271, 272. 1925. [An individual with dark red leaves with a green border, Monroe County, Indiana. See also *ibid.* 35: 179. 1926; seedlings from cleistogamous flowers were like the parent plant.]
- ARISUMI, T. Chromosome numbers and interspecific hybrids among New Guinea *Impatiens* species. *Jour. Hered.* 64: 77–79. 1973.*
- . Morphology and breeding behavior of colchicine-induced polyploid *Impatiens* spp. L. *Jour. Am. Soc. Hort. Sci.* 98: 599–601. 1973.*
- ARNOLD, A., & R. E. ALSTON. Certain properties of hypocotyl of *Impatiens Balsamina* reflecting physiological complexity. *Pl. Physiol.* 36: 650–656. 1961.
- BEAL, W. J. Fertilization of flowers by hummingbirds. *Am. Nat.* 14: 126, 127. 1880. [Observations by WM. SNYDER that the ruby-throated hummingbird is an effective pollinator of *I. capensis*, while bees are not. "*Impatiens fulva* is cross-fertilized mainly, if not wholly, by hummingbirds."]
- BECK, A. R., J. L. WEIGLE, & E. W. KRUGER. Breeding behavior and chromosome numbers among New Guinea and Java *Impatiens* species, cultivated varieties, and their interspecific hybrids. *Canad. Jour. Bot.* 52(5): 923–925. 1974.
- BENNETT, A. W. On the floral structure of *Impatiens fulva*, Nuttall, with especial reference to the imperfect self-fertilized flowers. *Jour. Linn. Soc. Bot.* 13: 147–153. *pl.* 3. 1873. [*I. capensis*; also cleistogamous flowers in *I. noli-tangere*.]
- . Notes on cleistogamic flowers; chiefly of *Viola*, *Oxalis*, and *Impatiens*. *Ibid.* 17: 269–280. 1880. [*I. noli-tangere*, *I. parviflora*, 276–278.]
- BEXON, D., & A. E. WOOD. Observations on the anatomy of teratological seedlings. VII. The anatomy of some polycotylous seedlings of *Impatiens Roylei*, Walp. *Ann. Bot.* 44: 297–309. 1930.
- BHASKAR, V. A new kind of exine sculpturing in *Impatiens* L. (Balsaminaceae) from south India. *Curr. Sci. Bangalore* 42: 510–512. 1973.*
- BIBB, P. C. Studies on the regulation of developmental sequences of anthocyanin pigmentation in cultured petals of *Impatiens Balsamina* L. *Diss. Abstr. B.* 28(9): 3596B. 1968.

- BOHM, B. A., & G. H. N. TOWERS. A study of phenolic compounds in *Impatiens*. *Canad. Jour. Bot.* **40**(5): 677-683. 1962. [In 16 spp.]
- BOYLEN, C. W., & C. W. HAGEN. Partial purification and characterization of a flavonoid-3-beta-D-glucoside from petals of *Impatiens Balsamina*. *Phytochemistry* **8**: 2311-2315. 1969.*
- BUNTING, G. A. Jewel weed *vs.* poison ivy. *Am. For. & For. Life* **30**: 495, 496. 1924. (Illustr.) [Tincture of *I. capensis* used in treating dermatitis caused by *Rhus radicans*.]
- CAMPBELL, I. M. Roles of alanine, aspartate and glutamate in lawsone biosynthesis in *Impatiens Balsamina*. *Tetrahedron Lett.* **54**: 4777-4780. 1969.*
- CARROLL, F. B. The development of the chasmogamous and the cleistogamous flowers of *Impatiens fulva*. *Contr. Bot. Lab. Univ. Penn.* **4**: 144-183. *pls.* 55-57. 1919. [*I. capensis*.]
- CHADEFAUD, M. Le pollen des impatiences et la theorie de Wodehouse. *Bull. Soc. Bot. France* **99**: 182, 183. 1952.
- CHAPELLE, J. P. 2-Methoxy-1, 4-naphthoquinone in *Impatiens glandulifera* and related species. *Phytochemistry* **13**: 662. 1974.*
- CHAUHAN, K. P. S., & W. O. ABEL. Evidence for the association of homologous chromosomes during premeiotic stages of *Impatiens* and *Salvia*. *Chromosoma* **25**: 297-302. 1968.
- CLEVENGER, S. The flavonols of *Impatiens Balsamina* L. *Arch. Biochem. & Biophys.* **76**: 131-138. 1958.*
- . The anthocyanidins of some *Impatiens* species. XI Int. Bot. Congr. Abstr. 34. 1969.
- COOMBE, D. E. Biological flora of the British Isles. *Impatiens parviflora* DC. *Jour. Ecol.* **44**: 701-713. [A very complete account.]
- CURTIS, S. *Impatiens glandulifera*. *Bot. Mag.* **49**: *pl.* 4020. 1843. [*I. glandulifera*.]
- DAHLGREN, K. V. O. Die Embryologie von *Impatiens Roylei*. *Sv. Bot. Tidskr.* **28**: 103-125. 1934. [*I. glandulifera*.]
- DAVIS, D. W., L. A. TAYLOR, & R. P. ASH. *Impatiens Balsamina* L. — the inheritance of floral colors. *Genetics* **43**: 16-34. 1958.
- ENGLEMAN, E. M. Sieve element of *Impatiens Sultanii*. 1. Wound reaction. 2. Developmental aspects. *Ann. Bot. II.* **29**: 83-118. *pls.* 1-9. 1965. [*I. Wallerana*.]
- FERNALD, M. L., & B. G. SCHUBERT. Studies of American types in British herbaria. *Rhodora* **50**: 149-176, 181-208, 217-233. *pls.* 1097-1117. 1948. [Note on *Impatiens biflora* Walt., 203-205; = *I. capensis* Meerb.]
- FIGIER, J. Infrastructural study of petiolar glands of *Impatiens Holstii*. (In French; English summary.) *Botaniste* **55**(1/6): 71-79. 1972.* [*I. Wallerana*.]
- FLYNN, J. J., JR. *Impatiens*. Pollen development, maturity, and germination. Diss., Univ. Massachusetts, 1969. *Diss. Dig. May 1970*: 14. 1970.* [Order No. 70-13, 209B.]
- FOURCROY, M., & J. BOULANGER. Ontogénie et anatomie de la plantule chez *Impatiens Balfouri* H.: Échantillons normaux et hétérocotylés. *Mém. Soc. Bot. France* **1963**: 154-186. 1964.
- FUCHS, H. P. Nomenklatorische Ergänzungen zu der Arbeit Nicholas Meerburg und die drei von Ihm verfassten botanischen Tafelwerke. *Acta Bot. Neerl.* **12**: 12-16. 1963. [*I. capensis* Meerb., 1775; the correct name for the plant known as *I. biflora* Walt. See also G. M. SCHULZE, *Notizbl.*

- Bot. Gart. Berlin 13: 665. 1937; B. L. BURTT, Bull. Misc. Inf. Kew 1938: 161-163. 1938; M. L. FERNALD, *Rhodora* 50: 203-205. *pl.* 1108. 1948.]
- GILG, E. Balsaminaceae africanae. Bot. Jahrb. 43: 97-128. 1909. [85 spp. in Africa; pp. 118-120, discussion of *Impatiens Wallerana* Hook. f., *I. Sultani* Hook. f., *I. Holstii* Engler & Warb., of sect. *Longicornes* Warb.; combines all under *I. Wallerana*.]
- GRAY, A. Ord. Balsaminaceae. Gen. Pl. U. S. 2: 131-136. *pls.* 152, 153. 1849. [*I. fulva* (= *I. capensis*), *pls.* 152, 153; cleistogamous flowers, *pl.* 153.]
- GRONER, M. G. Sugar excretion in *Impatiens Sultani*. Am. Jour. Bot. 26: 464-467. 1939. [Excretion of sucrose by petiolar hairs in plants of *I. Wallerana*.]
- GROTZINGER, E., & I. M. CAMPBELL. Intermediate symmetry in lawsone biosynthesis. Phytochemistry 11: 481-488. 1972.* [*I. Balsamina*.]
- HAGEN, C. W. The production of pigments in flowers of *Impatiens Balsamina*. (Abstr.) Proc. Indiana Acad. Sci. 66: 61. 1957.
- HEGARTY, T. W. Seedling growth in controlled-nutrient conditions. Jour. Exper. Bot. 24: 130-137. 1973.* [*I. parviflora*.]
- HOLM, T. Sciaphilous plant-types. Beih. Bot. Centralbl. 44: 1-89. 1927. [*I. fulva*, 56, = *I. capensis*.]
- HOOKER, J. D. *Impatiens Roylei* var. *pallidiflora*. Bot. Mag. 125: *pl.* 7647. 1899. [*I. glandulifera* Royle f. *pallidiflora* (Hook. f.) Weatherby.]
- . An epitome of the British Indian species of *Impatiens*. Rec. Bot. Surv. India 4: 1-10. 1904; 11-35. 1905; 37-58 + iii (index). 1906.
- HUANG, T. C. A revision of Formosan *Impatiens* (Balsaminaceae). Taiwania 18: 49-54. 1973. [3 species.]
- HUGHES, A. P. The importance of light compared with other factors affecting plant growth. Brit. Ecol. Soc. Symp. 6: 121-146. 1966. [Review of the literature; chiefly *I. parviflora*.]
- HUYNH, K. L. Cinq espèces d'*Impatiens* au pollen insolite. (English summary.) Pollen Spores 8: 455-460. 1966. [5 Asiatic spp. of 440 spp. surveyed have "spinulate" pollen; others have reticulate.]
- . Le déterminisme de l'emplacement des ouvertures sur le pollen d'une espèce à quatre ouvertures: *Impatiens scabrida* DC. Grana Palyn. 7: 37-45. 1967.
- IWANAMI, Y. Physiological researches of pollen VII. The starch grain in the pollen of *Impatiens Balsamina* L. (In Japanese; Esperanto summary.) Bot. Mag. 67: 134-137. 1954.
- & N. NAKAMURA. Storage in an organic solvent as a means for preserving viability of pollen grains. Stain Technol. 47: 136-139. 1972. [*Lilium*, *Camellia*, *Impatiens*.]
- JASNOWSKI, M. *Impatiens Roylei* Walpers, a new forest meadow plant in Poland. (In Polish; German summary.) Polska Akad. Nauk. Inst. Bot. Mater. Florystyczne Geobot. 7(1): 77-80. 1961.*
- JENNINGS, O. E. *Impatiens pallida* forma *speciosa* f. nov. Ohio Jour. Sci. 20: 204. 1920.
- JONES, K., & J. B. SMITH. The cytogeography of *Impatiens* L. (Balsaminaceae). Kew Bull. 20: 63-72. 1966. [Includes counts on 25 spp., $2n = 14, 16, 18, 20, 34, 36 (+ 2f), 66$.]
- KHOSHOO, T. N. Cytology of *Impatiens*. Cur. Sci. Bangalore 24: 423, 424. 1955.*
- . Chromosomes from herbarium sheets of *Impatiens*. Stain Technol.

- 31: 31-33. 1956. [Counts obtainable from generative nucleus in prometaphase in pollen grains.]
- . Cytology of some *Impatiens* species. *Caryologia* 10: 55-74. *pl.* 13. 1957. [Includes table listing known chromosome counts in *Impatiens*.]
- . Cytology of pollen with particular reference to *Impatiens* and Alliaceae. *Proc. Indian Acad. Sci. B.* 63: 35-45. 1966.*
- KLEIN, A. O., & C. W. HAGEN. Anthocyanin production in detached petals of *Impatiens Balsamina* L. *Pl. Physiol.* 36: 1-9. 1961.
- KRISHNAMOORTHY, H. N., & K. K. NANDA. Floral bud reversion in *Impatiens Balsamina* under non-inductive photoperiods. *Planta* 80: 43-51. 1968.
- KROEGER, G. S. Dormancy in seeds of *Impatiens Balsamina* L. *Contr. Boyce Thompson Inst.* 12: 203-212. 1941.
- LAUNERT, E. Balsaminaceae. *In*: A. W. EXELL, A. FERNANDES, & H. WILD, eds., *Fl. Zambesiaca* 2(1): 162-180. 1963. [22 spp. of *Impatiens*; *I. Wallerana*, 166.]
- LEBON, E. Sur la formation de l'albumen chez *Impatiens Sultani*. *Comp. Rend. Soc. Biol. Paris* 101: 1168-1170. 1929. [*I. Wallerana*.]
- LE SAINT-QUERVEL, A. M. Étude anatomique de quelques plantules anormales d'*Impatiens Roylei* W. *Revue Gén. Bot.* 62: 373-391. 1955.
- LOISEAU, J. E. Observations et expérimentation sur la phyllotaxie et le fonctionnement du sommet végétatif chez quelques Balsaminacées. *Ann. Sci. Nat. Bot. XI.* 20: 1-214. *pls.* 41-60. 1959. [Republished as Thèse, Fac. Sci. Univ. Paris Ser. A, No. 3229. 1959. Includes *I. capensis* and *I. glandulifera* (as *I. Roylei*)].
- LOW, E. Der Blütenbau und die Bestäubungseinrichtung von *Impatiens Roylei* Walp. *Bot. Jahrb.* 14: 166-182. *pls.* 1, 2. 1892.
- MANSELL, R. L., & V. L. KEMERER. Qualitative and quantitative comparisons of hydroxycinnamic acid derivatives in petals of red (llHHPrPr), white (llhhpp) and purple (LLhhPrPr) genotypes of *Impatiens Balsamina*. *Phytochemistry* 9: 1751-1755. 1970.*
- & J. A. SEDER. O-methyltransferase activity from young flower petals of *Impatiens Balsamina*. *Ibid.* 10: 2043-2045. 1971.*
- MEHRA, K. L., N. RISHI, & H. KESHORE. Introgression between *Impatiens racemosa*, *Impatiens laxiflora*, and *Impatiens scabrida*. *Proc. Indian Acad. Sci. B.* 71: 133-144. 1970.*
- MEYER, R. R., & E. R. WALKER. The vegetative anatomy of *Impatiens pallida*. *Trans. Am. Micros. Soc.* 50: 1-19. 1931.
- MILES, C. D., & C. W. HAGEN. The differentiation of pigmentation in flower parts. IV. Flavonoid elaborating enzymes from petals of *Impatiens Balsamina*. *Pl. Physiol.* 43: 1347-1354. 1968.
- NAIR, P. K. K. A note on pollen germination at various stages of development of flower buds of balsam (*Impatiens Balsamina*). *Jour. Palynol.* 9: 29-33. 1973.
- NARAYANA, L. L., & M. SAYEEDUDDIN. A study of the gametophytes in *Impatiens Leschenaultii* Wall. *Jour. Indian Bot. Soc.* 38: 391-397. 1959.
- ORNDUFF, R. *Impatiens capensis* in Oregon: native or naturalized? *Leaf. West. Bot.* 10: 317-319. 1966. [Evidence inconclusive; apparently indigenous in a small area of northwestern Washington and southwestern British Columbia.]
- . Hybridization and regional variation in Pacific northwestern *Impatiens* (Balsaminaceae). *Brittonia* 19: 122-128. 1967.

- OTTLEY, A. M. A contribution to the life history of *Impatiens Sultani*. Bot. Gaz. 66: 289-317. pls. 14, 15. 1918. [*I. Wallerana*.]
- PANDEY, K. K., & G. W. BLAYDES. Cytoplasmic inheritance of plastids in *Impatiens Sultanii* Hook. f., *Petunia violacea* Lindl. and *Chlorophytum elatum* R. Br. Ohio Jour. Sci. 57: 135-147. 1957.
- PHOUPHAS, C. Nouvelles observations embryogéniques sur les *Impatiens*. Bull. Soc. Bot. France 98: 238-241. 1951.
- RACKHAM, O. Radiation, transpiration, and growth in a woodland annual. Brit. Ecol. Soc. Symp. 6: 167-185. 1966. [*I. parviflora* and solar radiation.]
- RAGHAVAN, T. S., K. R. VENKATASUBBAAN, & H. D. WULFF. Division of the generative cell in *Impatiens Balsamina* L. Cytologia 9: 389-392. 1939.
- RAGHUVANSHI, S. S., & S. JOSHI. Investigation on the frequency of B-chromosomes in *Impatiens Balsamina* and the appearance of single flowers on double varieties. Genetica 39: 544-552. 1968.
- RAITT, A. H. Development of the ovule of *Impatiens pallida* Nutt. Pl. World 19: 195-203. 1916.
- RICHTER-LANDMANN, W. Der Befruchtungsvorgang bei *Impatiens glandulifera* Royle unter Berücksichtigung der plasmatischen Organelle von Spermazelle, Eizelle und Zygote. Planta 53: 162-177. 1959.
- RICKETT, H. W. Wildflowers of the United States. Vol. 2. The Southeastern States. Part 2. Pp. i-vi + 323-688. New York. 1966. [*Impatiens*, 366, pl. 131.]
- ROBERTSON, C. Flowers and insects. III. Bot. Gaz. 14: 297-304. 1889. [Pollination of *I. capensis* & *I. pallida*, 301; see also Flowers and Insects. 221 pp. Carlinville, Illinois. 1928; *Impatiens*, 36, 37.]
- SAWHNEY, S., N. SAWHNEY, & K. K. NANDA. Partial substitution by long days of short days required for floral induction in *Impatiens Balsamina*. Pl. Cell Physiol. 13: 1123-1127. 1972.*
- SCHLECHTER, R. Die Balsaminaceae Papuasiens. Bot. Jahrb. 55: 114-120. 1917. [8 spp.]
- SENAY, P. *Impatiens fulva* Nutt. sur les rives de la basse Seine. Bull. Soc. Bot. France 77: 257-259. 1930. [*I. capensis*.]
- SHIMIZU, T. Contributions to the flora of southeast Asia. II. *Impatiens* of Thailand and Malaya. Tonan Ajia Kenkyu (Southeast Asian Studies) 8: 187-217. 1970. [47 spp.]
- SHIVANNA, K. R. Inhibition of gamete formation by cycloheximide in pollen tubes of *Impatiens Balsamina*. Planta 117: 173-177. 1974.
- SINGH, T. C. N., & S. PONNIAH. On the response of structure of the leaves of balsam (*Impatiens Balsamina*) and mimosa (*Mimosa pudica*) to the musical sounds of violin. Indian Sci. Cong. Assoc. Proc. 42(3, abstr.): 254. 1955.*
- SMITH, F. H. Prochromosomes and chromosome structure in *Impatiens*. Proc. Am. Philos. Soc. 74: 193-214. pls. 1-3. 1934.
- . Anomalous spindles in *Impatiens pallida*. Cytologia 6: 165-176. 1935.
- . Reduction divisions in triploid *Impatiens*. Am. Jour. Bot. 25: 651-654. 1938.
- SOHMA, K. Pollen morphology of Japanese species of *Impatiens*, with notes on first fossil record of genus in Japan. Tohoku Univ. Sci. Rep. 4. (Biol.) 35: 259-262. 1971.*
- SOUÈGES, R. Embryogénie des Balsaminacées. Développement de l'embryon

- chez l'*Impatiens Balfourii* Hook. Compt. Rend. Acad. Sci. Paris 220: 837–840. 1945.
- STEFFEN, K. Zur Kenntnis des Befruchtungsvorganges bei *Impatiens glandulifera* Lindl. Cytologische studien am Embryosack der Balsamineen. *Planta* 39: 175–244. 1951. [*I. glandulifera*.]
- . Die Embryoentwicklung von *Impatiens glandulifera* Lindl. *Flora* 139: 394–461. 1952. [Detailed account of embryo development.]
- & W. LANDMANN. Entwicklungsgeschichtliche und cytologische Untersuchungen am Balkentapetum von *Gentiana cruciata* L. und *Impatiens glandulifera* Royle. *Planta* 50: 423–460. 1958.
- STEWART, S. E. Breaking male sterility in *Impatiens Sultani* Hook. f. by hybridization (Malvales: Balsaminaceae). (Abstr.) *ASB Bull.* 18: 57. 1971. [*I. Wallerana*.]
- STIPPERGER-BRAT, L., & F. WEBER. Nyktinastie bei *Impatiens*. *Phyton Austria* 5: 34–37. 1953. [*I. Holstii* = *I. Wallerana*.]
- TAKAO, S. A study on the development of embryo sac in *Impatiens textori*. *Bot. Mag. Tokyo* 81: 310–317. 1968.
- TARA, C. P. Aberrant microsporogenesis and sterility in *Impatiens Sultani* (Balsaminaceae). *Am. Jour. Bot.* 61: 585–591. 1974.
- TAYLOR, L. A. Plants used as curatives by certain southeastern tribes. Part I. Plants used medicinally. xi + 88 pp. *Bot. Mus., Harvard Univ., Cambridge, Mass.* 1940. [*Impatiens capensis*, 40.]
- TOKY, K. L., & K. K. NANDA. Hastening effect of intercalated long days on short-day induction in *Impatiens Balsamina*, a qualitative short day plant. *Planta* 89: 198–202. 1969.
- TRELEASE, W. *Impatiens fulva*, action of bees toward. *Bull. Torrey Bot. Club* 7: 20, 21. 1880. [Honeybees visiting flowers of *I. capensis* with perforated and nonperforated nectaries.]
- VALENTINE, D. H. Flower-colour polymorphism in *Impatiens glandulifera* Royle. *Boissiera* 19: 339–343. 1971.
- VAZART, J. Étude cytologique du genre *Impatiens*. II. Premiers stades du développement de l'ovule et prophase heterotypique ♀ chez *I. Balfourii*. *Revue Cytol. Biol. Vég.* 19: 311–336. 1958.*
- WEATHERBY, C. A. Color forms of *Impatiens biflora*. *Rhodora* 19: 115–118. 1917. [*I. capensis*.]
- . Further notes on *Impatiens biflora*. *Ibid.* 21: 98–100. 1919. [*I. capensis*.]
- . *Impatiens Roylei* versus *I. glandulifera*. *Ibid.* 48: 412–414. 1946. [Correct name is *I. glandulifera*.]
- WEBER, F. *Impatiens* nektar. *Phyton Austria* 3: 110, 111. 1959. [*I. Holstii* = *I. Wallerana*.]
- WEIJER, J. Studies on *Impatiens Balsamina* L. I. The inheritance of flower colour and its bearing on the phenomenon of cumulative linked isomery. *Genetica* 29: 358–384. 1959; II. The inheritance of flower doubleness and its dependence on gibberellic acid, indoleacetic acid and related compounds. *Ibid.* 30: 70–107. 1959; III. The inheritance of dilute and very dilute flower colours. *Canad. Jour. Genet. Cytol.* 2: 175–183. 1960.
- WEISSENBOCK, G., & H. REZNICK. Changes in flavonoid pattern during germination of *Impatiens Balsamina* L. seeds. (In German.) *Zeitschr. Pflanzenphysiol.* 63: 114–130. 1970.*

WILLE, W. Labelling experiments in relation to the kinetics of leucoanthocyanin and anthocyanin synthesis in the hypocotyls of *Impatiens Balsamina* L. (In German; English summary.) *Zeitschr. Pflanzenphysiol.* **57**: 134–150. 1967.*

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